

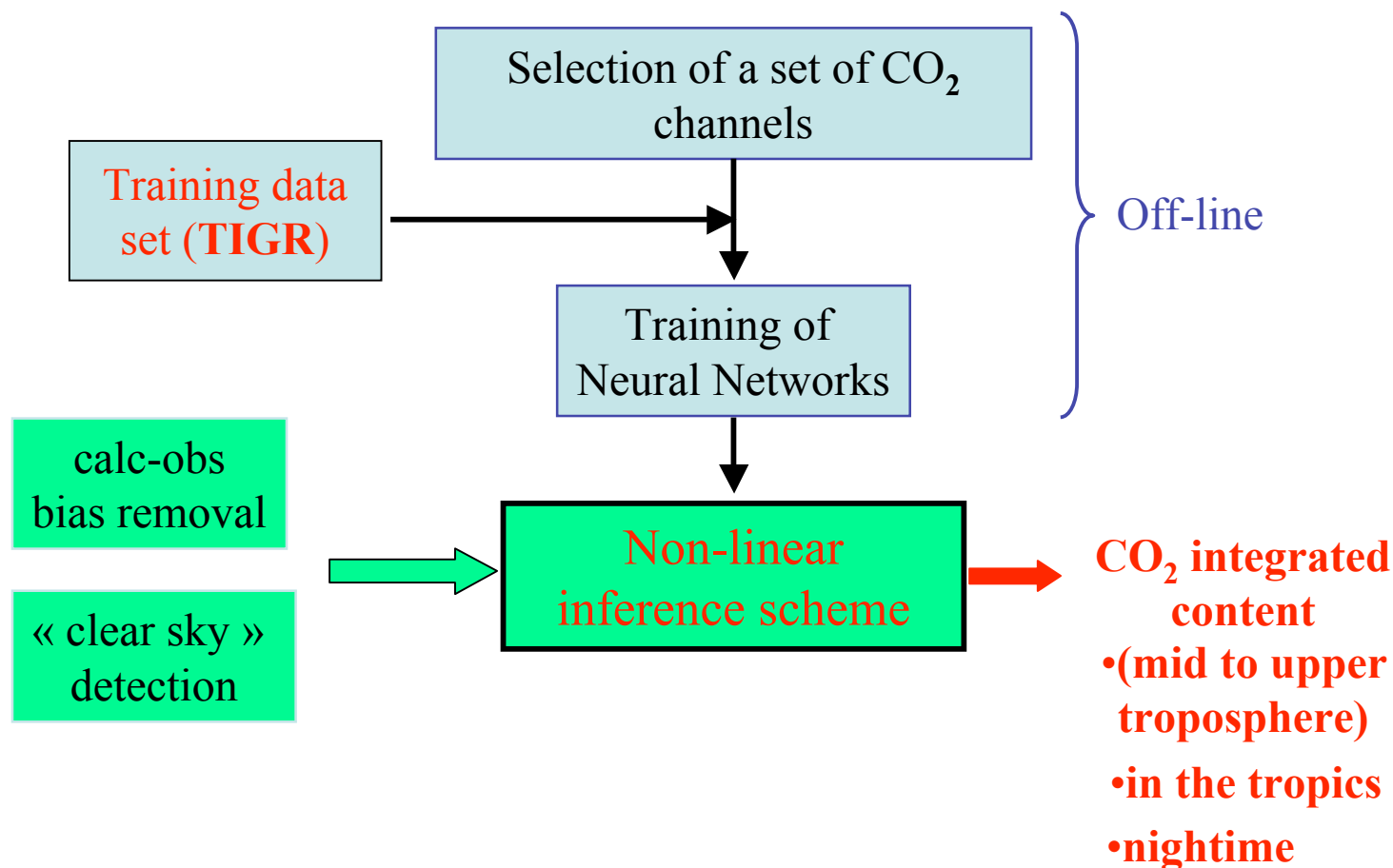
Retrieving mid to upper tropospheric CO₂ columns from AIRS - revisited

LMD/IPSL/ARA, Ecole Polytechnique, France

AIRS Science Meeting, March 2006

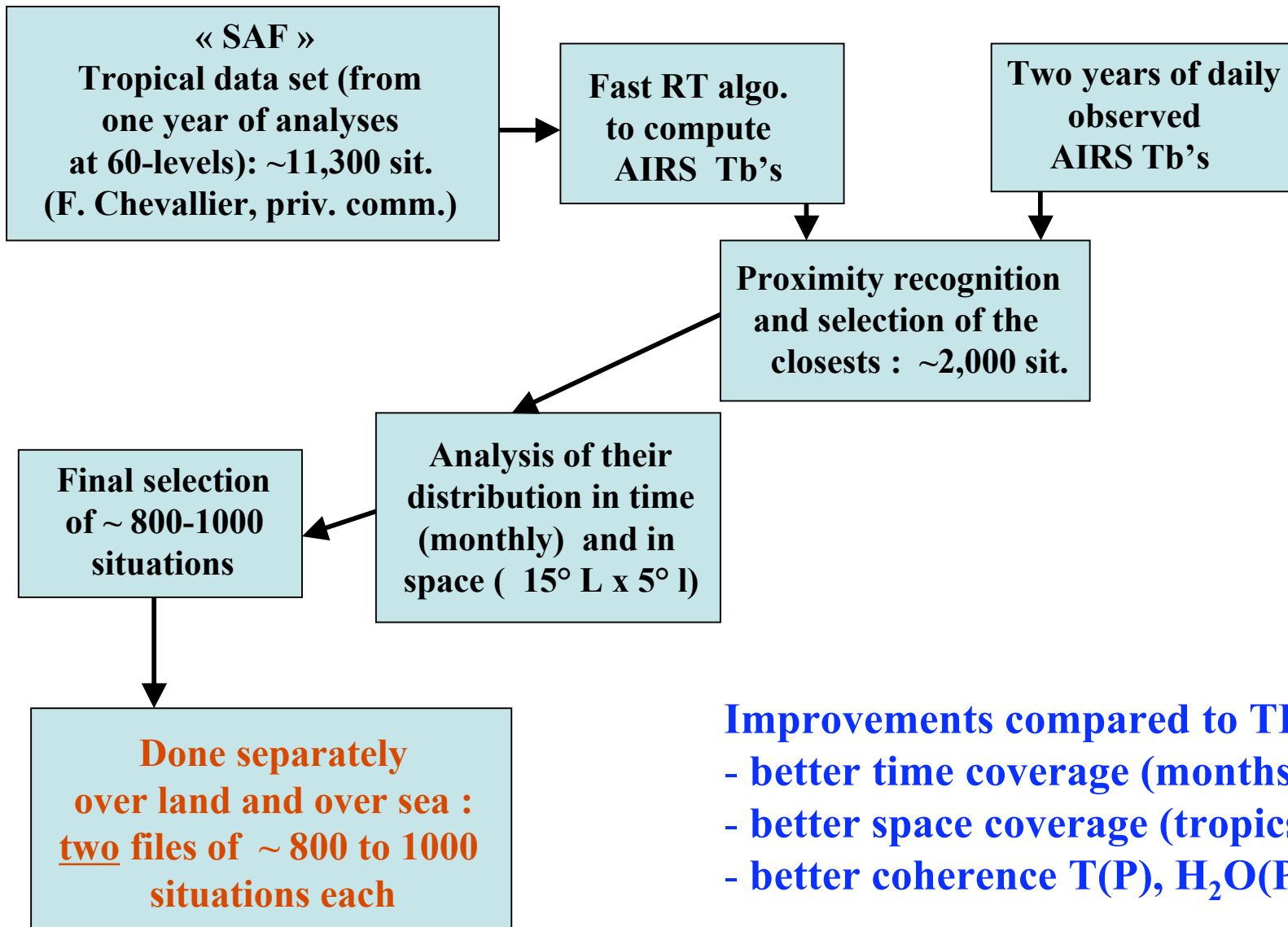
General features of the CO₂ retrieval scheme: non-linear regressions

[Chédin et al., JGR, 2003 - Crevoisier et al., GRL, 2004]



Since April 2003, LMD has stored AIRS/AMSU observations distributed by NOAA/NESDIS with the highest spatial resolution available.

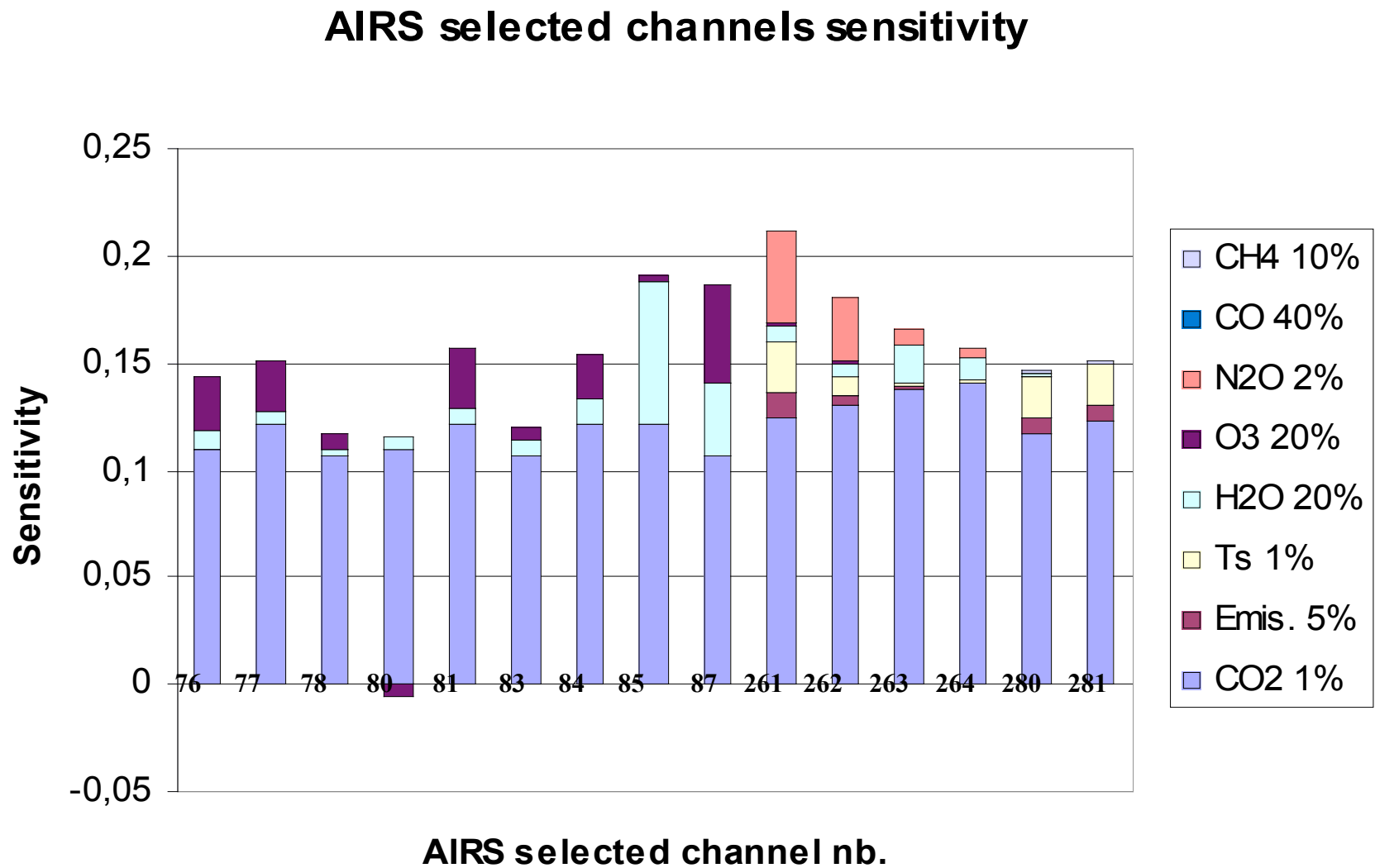
Design of a new learning data base (SAF-TIGR)



Improvements compared to TIGR:

- better time coverage (months, seasons)
- better space coverage (tropics)
- better coherence T(P), H₂O(P), O₃ (P)

Revised AIRS channel selection (15 AIRS and 2 AMSU)



AIRS cloud and aerosol detection algorithm revisited (current version “V8” tightened)

Aim: detect clear columns (thin cirrus, low clouds and aerosols may contaminate observations)

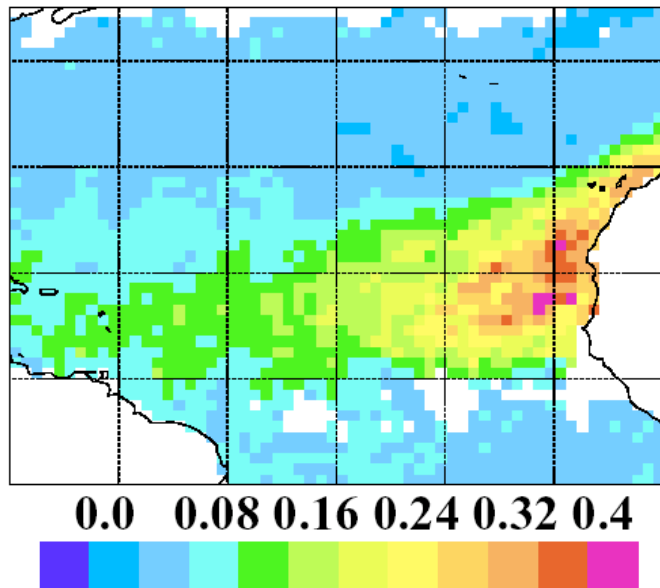
13 tests based on observed channel difference histograms

Thresholds determined from the observations

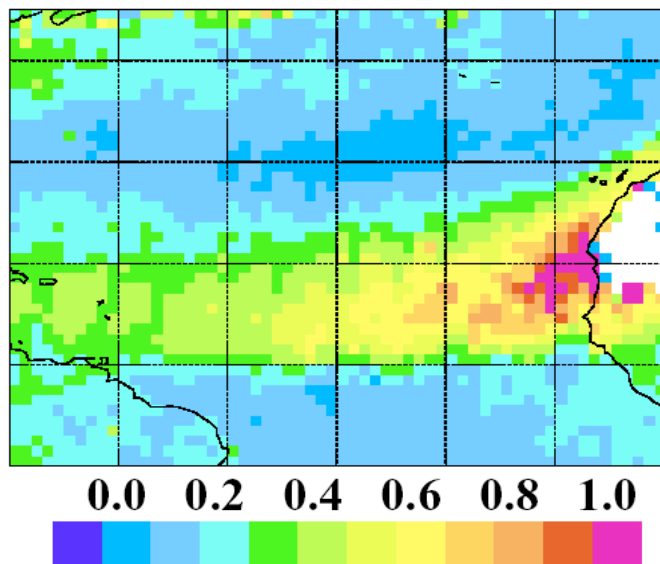
Dedicated tests for low clouds and/or aerosols (channels selected from simulations using the “4A - DISORT” radiative transfer model), for mid clouds, and for high clouds (cirrus, thin cirrus)

“Validation” using MODIS: AIRS cloud cover should be significantly larger due to lower spatial resolution)

AIRS (10 μm)



MODIS (0.55 μm)



Undetected aerosols may contaminate CO_2 retrievals

Dedicated AIRS cloud tests allow separating aerosols from low clouds

Infrared (10 μm) aerosol optical depths and altitude may then be calculated [Pierangelo et al., 2004]

Results for **July 2003**

Bottom left figure shows the results obtained from **MODIS** in the visible (0.55 μm)

Note the strong signature of dust aerosols crossing the Atlantic ocean

AIRS cloud tests (night, sea, “version 8”)

Test nb	Test*	Threshold (K)	cloud type
1	93 – A6 GT	1.0	high
2	264 – A6 GT	1.0	high
3	280 – A6 GT	1.0	high
5	284 – A5 GT	1.0	mid
6	284 – A6 GT	1.0	mid
7	286 – A5 GT	1.0	low
8	136 – 308 GT	2.0	surf
9	136 – 315 GT	2.0	surf
10	315 – 140 LT	0.7	low clouds
11	315 – 140 GT	3.3	cirrus
12	313 – 177 GT	1.8	high clouds
13	313 – 177 LT	0.8	aerosols

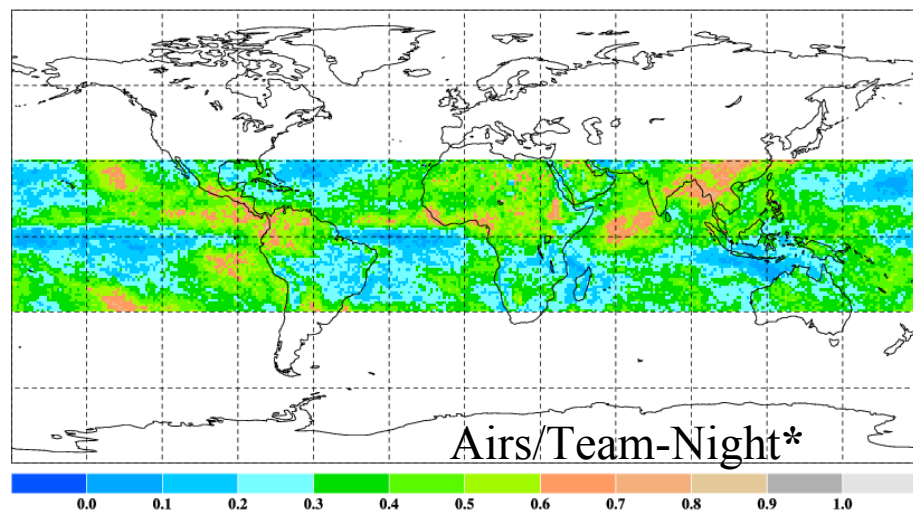
93	14.08
136	10.90
140	10.36
177	8.14
264	4.428
280	4.192
286	4.182
313	3.835
315	3.822

Wavelength of the channels
used (μm)

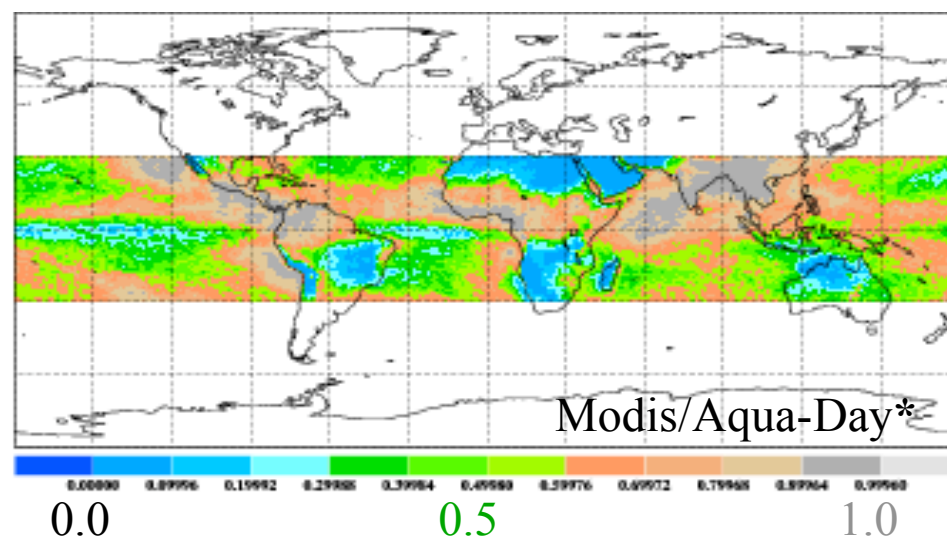
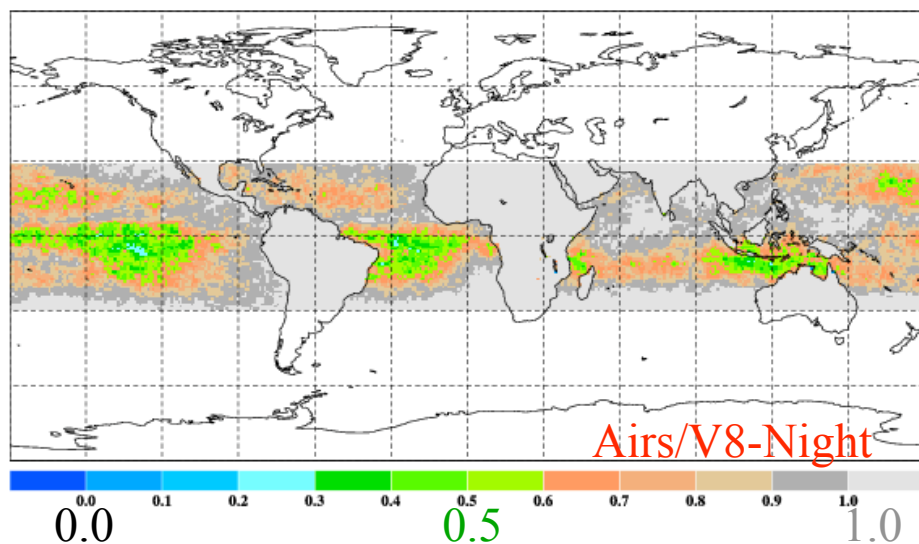
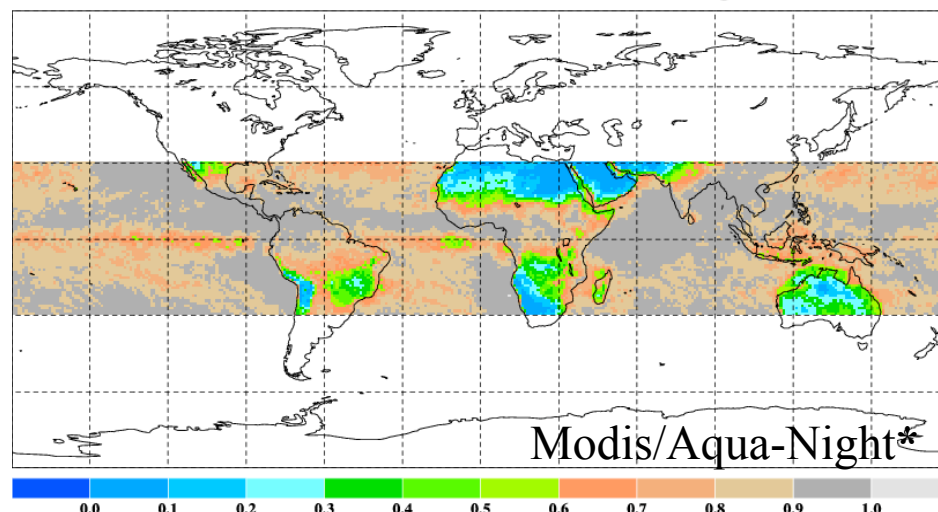
* n° on the 324 channel list ; A5-6 : AMSU channels

Cloud fraction from AIRS and MODIS: still big differences (June 2003)

June 2003 : AIRS AQUA cloud fraction (night)



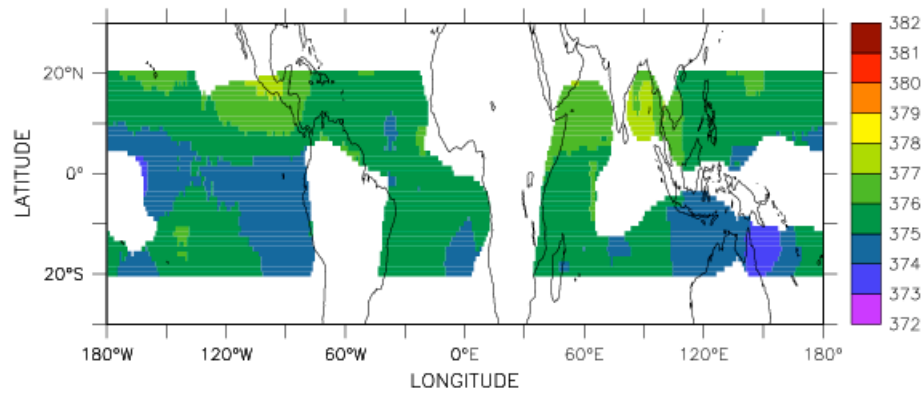
June 2003 : MODIS AQUA cloud fraction (night)



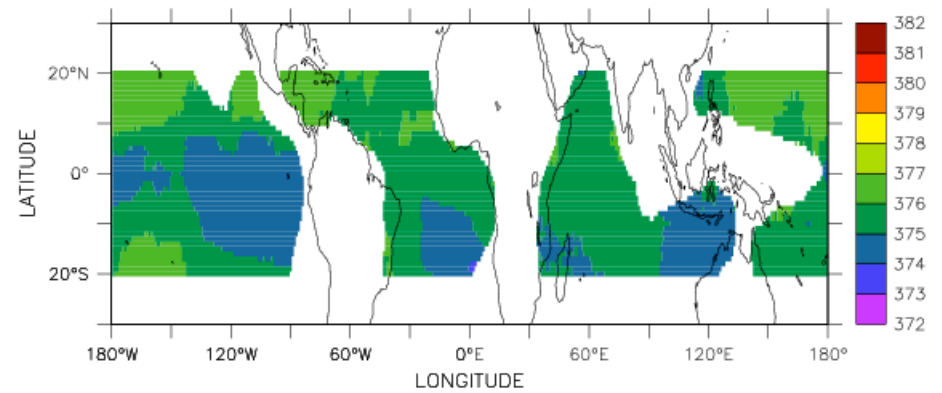
*<http://daac.gsfc.nasa.gov/data/datapool/>

Example of AIRS CO₂ fields

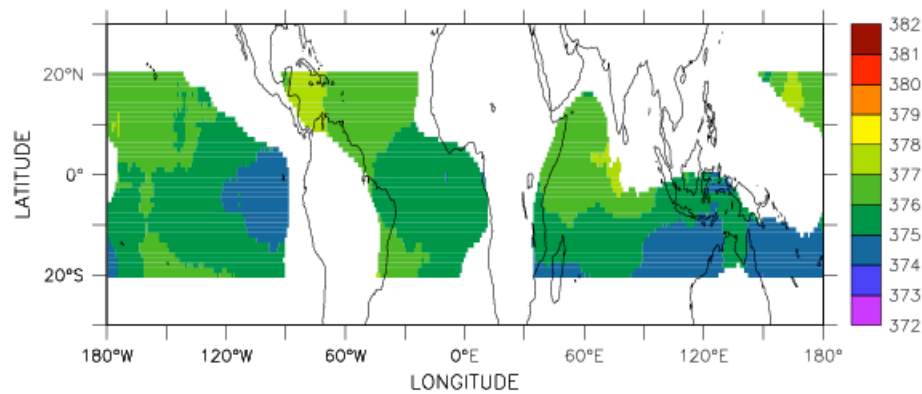
April – July 2004



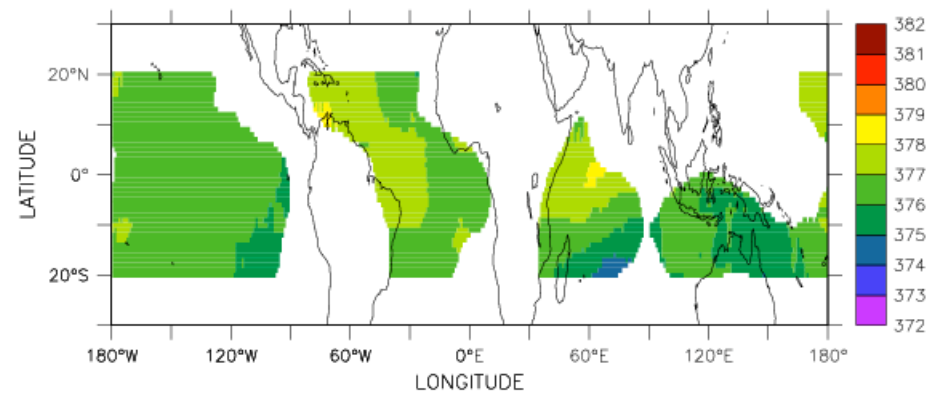
070751 c bruit TB divis par 215 04/2004



070751 c bruit TB divis par 215 05/2004



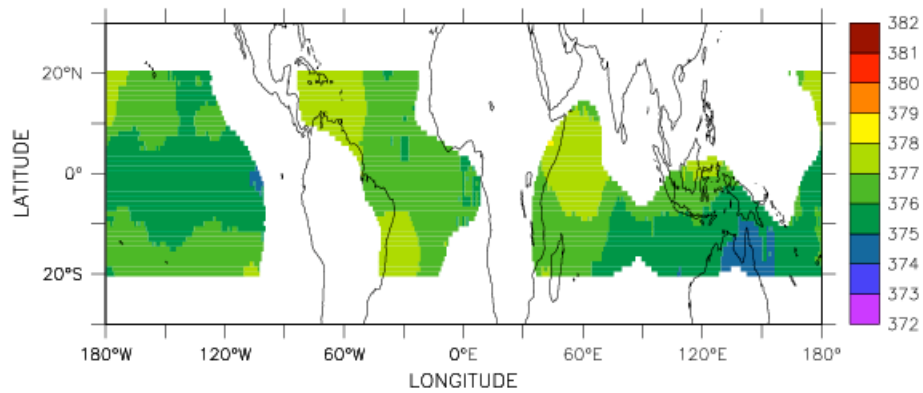
070751 c bruit TB divis par 215 06/2004



070751 c bruit TB divis par 215 07/2004

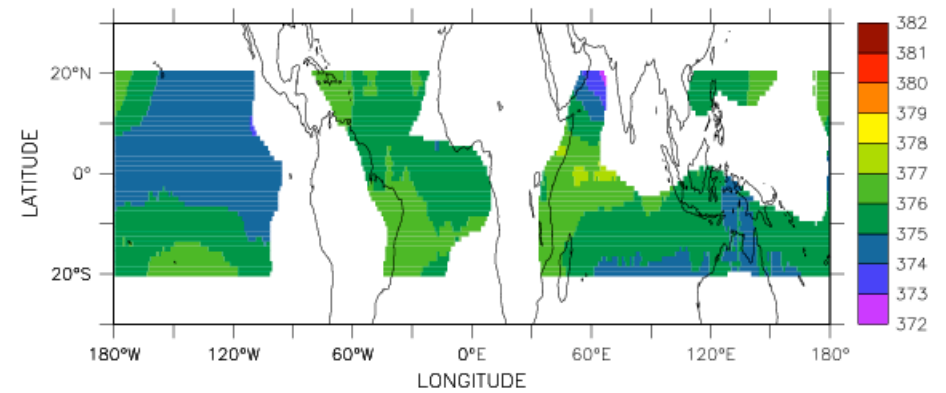
Example of AIRS CO₂ fields

August – November 2004



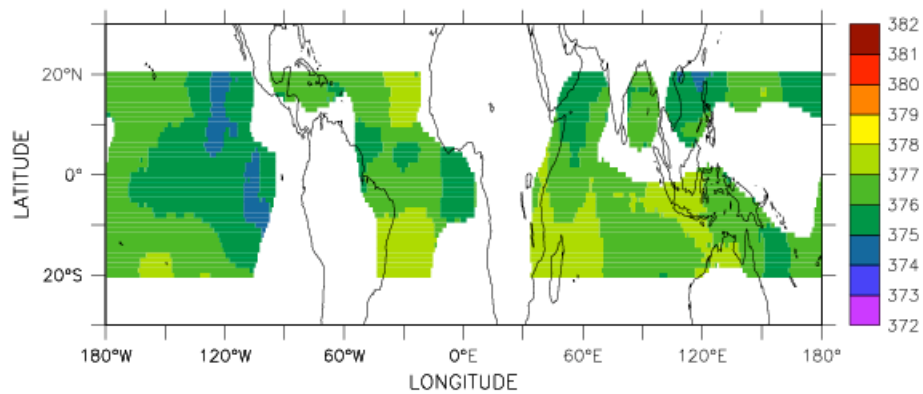
070751 c bruit TB divis par 215

08/2004



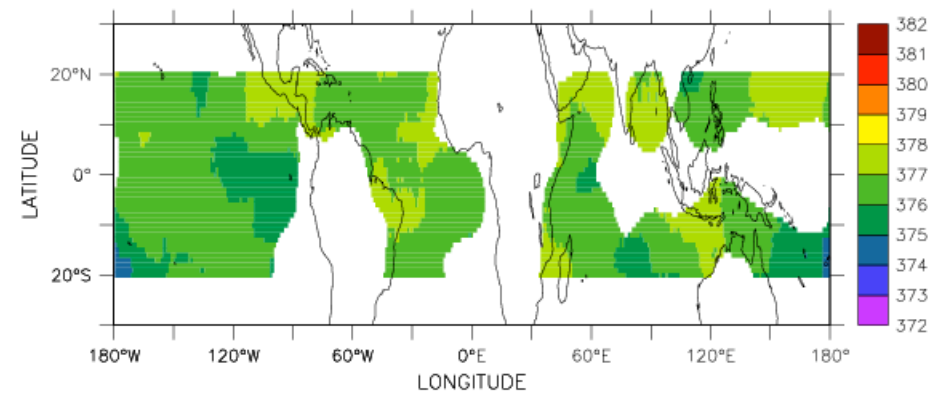
070751 c bruit TB divis par 215

09/2004



070751 c bruit TB divis par 215

10/2004



070751 c bruit TB d'

Comparison with aircraft measurements* from April 2003 to March 2005 (Japan to Australia)

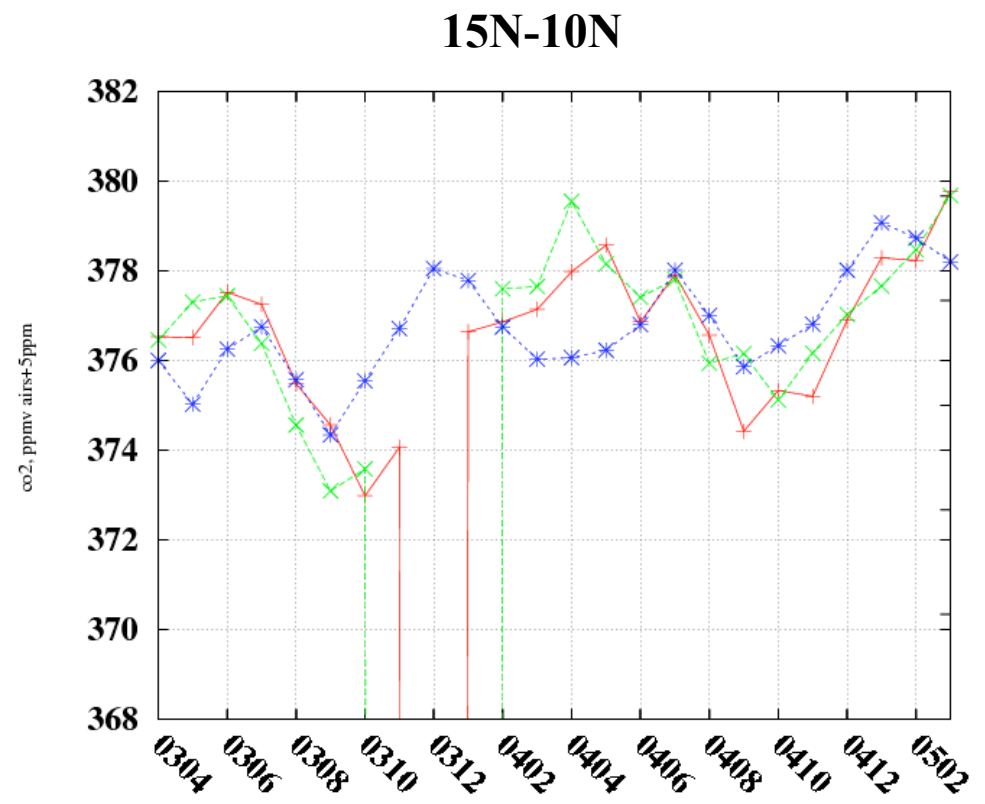
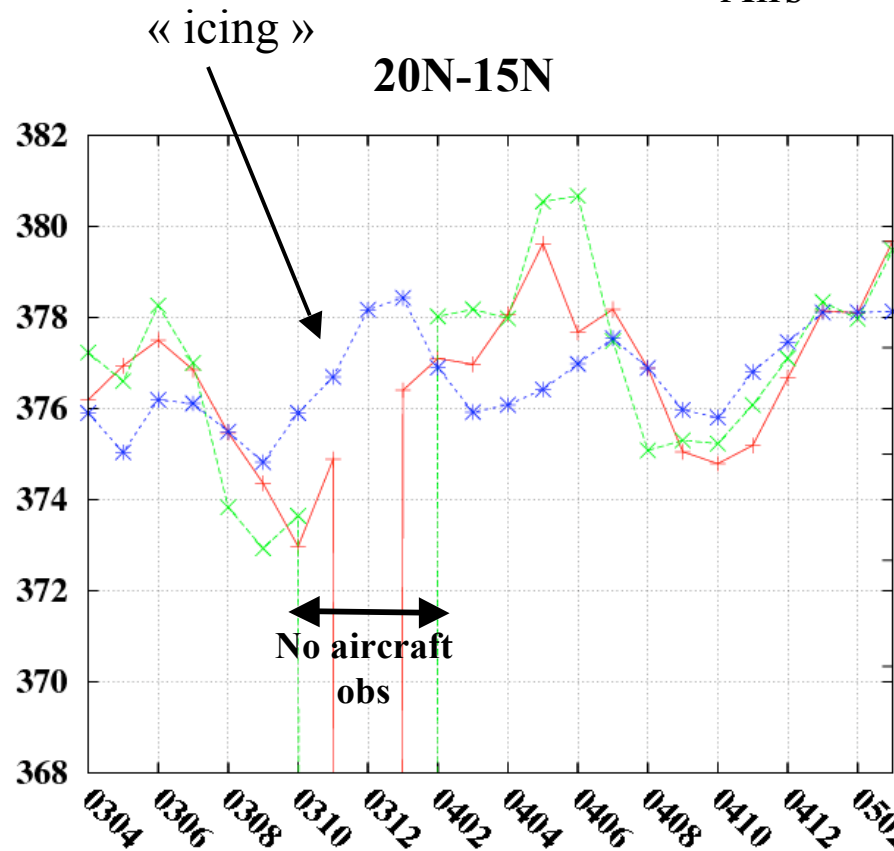
Limits of the comparison:

- (a) satellite retrievals integrate the mid-to-high troposphere (max contribution between ~6-16 km) when the aircraft flies at 10-11 km**
- (b) only 2 aircraft measurements per month at variable dates**
- (c) the region is dominated by convection from the warm pool: large gaps due to clouds**
- (d) the number of individual ($1^\circ \times 1^\circ$) retrievals to be averaged may be too small : average done over the longitudes from 120° to 180° E for each 5° latitude band, when the aircraft flies at $\sim 145^\circ$ E**
- (e) the number of individual ($1^\circ \times 1^\circ$) retrievals to be averaged may however remain too small (meaningless results)**

***H. Matsueda, private comm., 2005**

Comparison AIRS – Aircraft

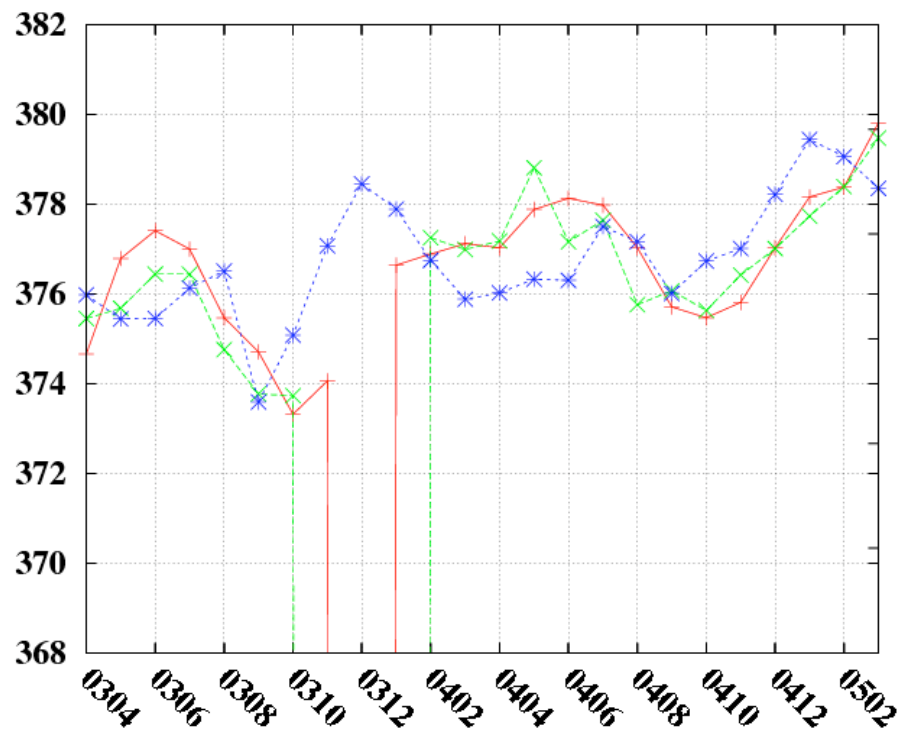
- Aircraft 1st part of the month
- Aircraft 2nd part of the month
- Airs



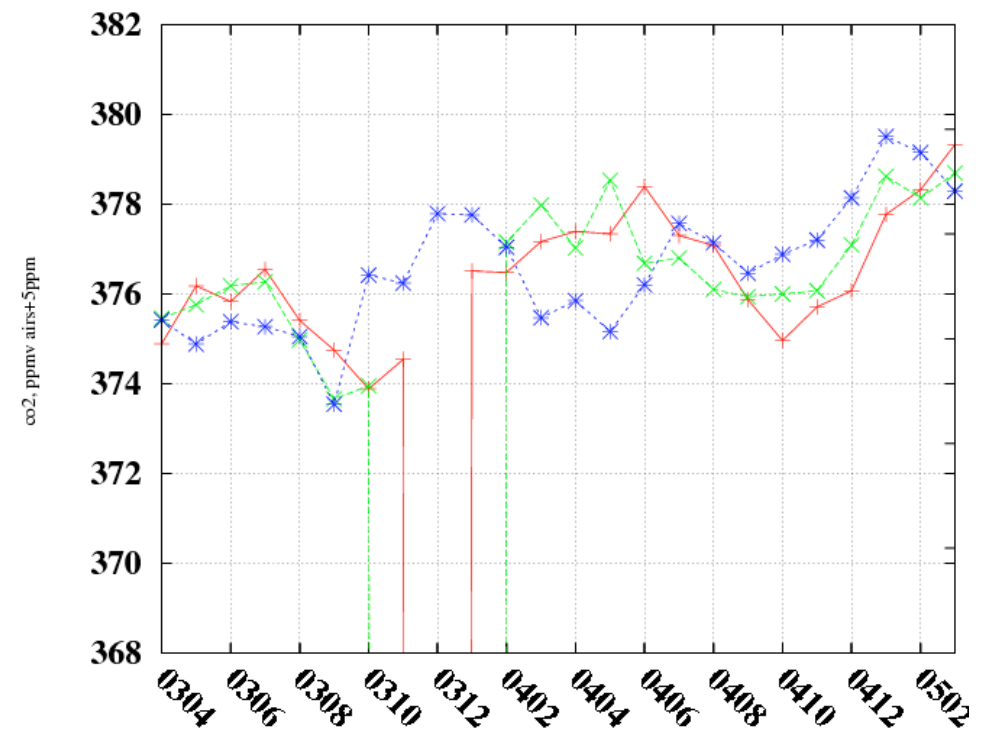
Comparison AIRS – Aircraft

- Aircraft 1st part of the month
- Aircraft 2nd part of the month
- AIRS

10N-05N



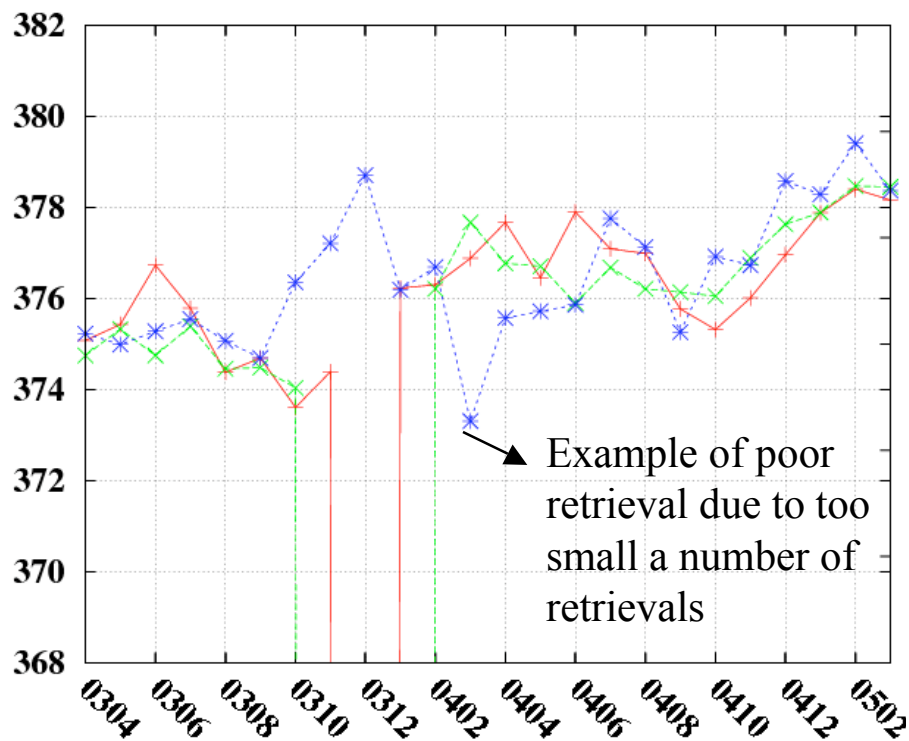
05N-EQ



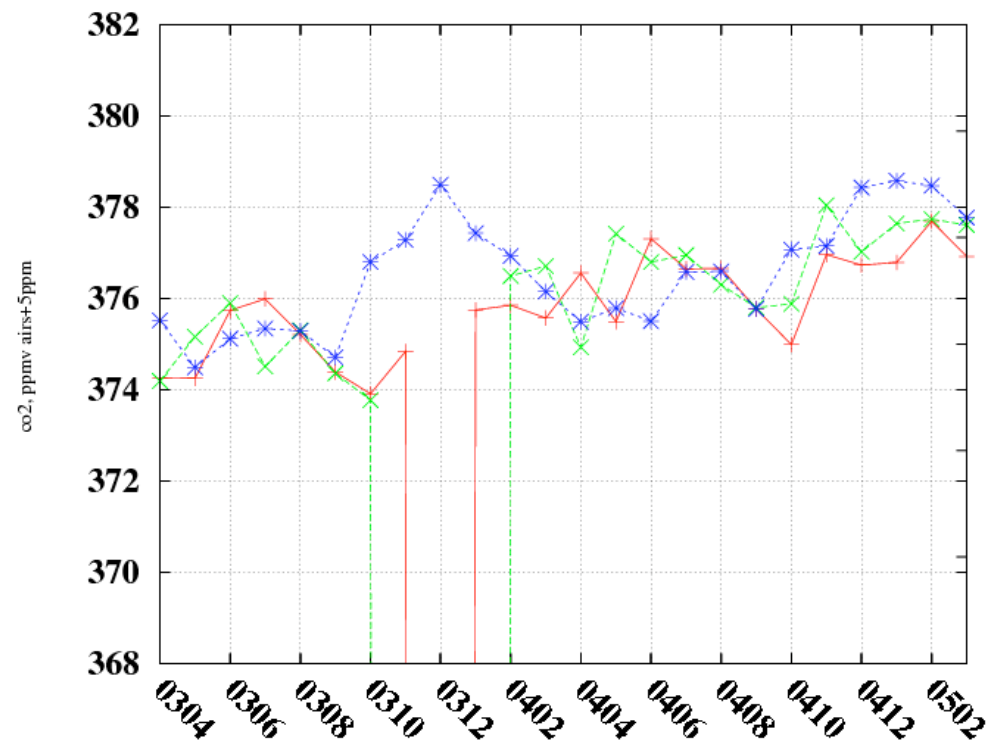
Comparison AIRS – Aircraft

- Aircraft 1st part of the month
- Aircraft 2nd part of the month
- AIRS

EQ-05S



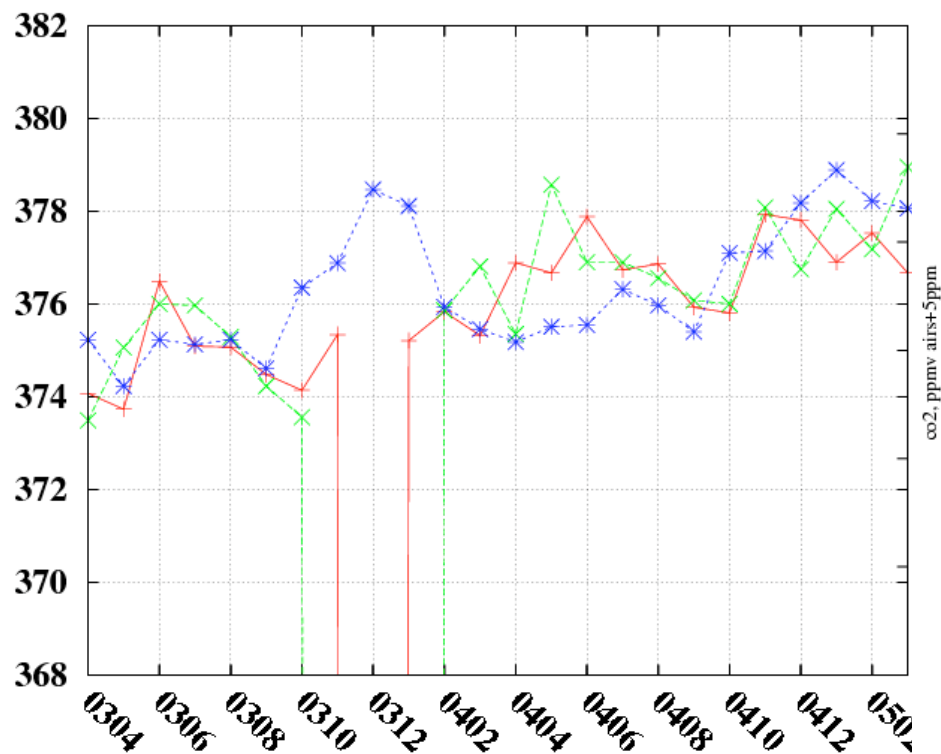
05S-10S



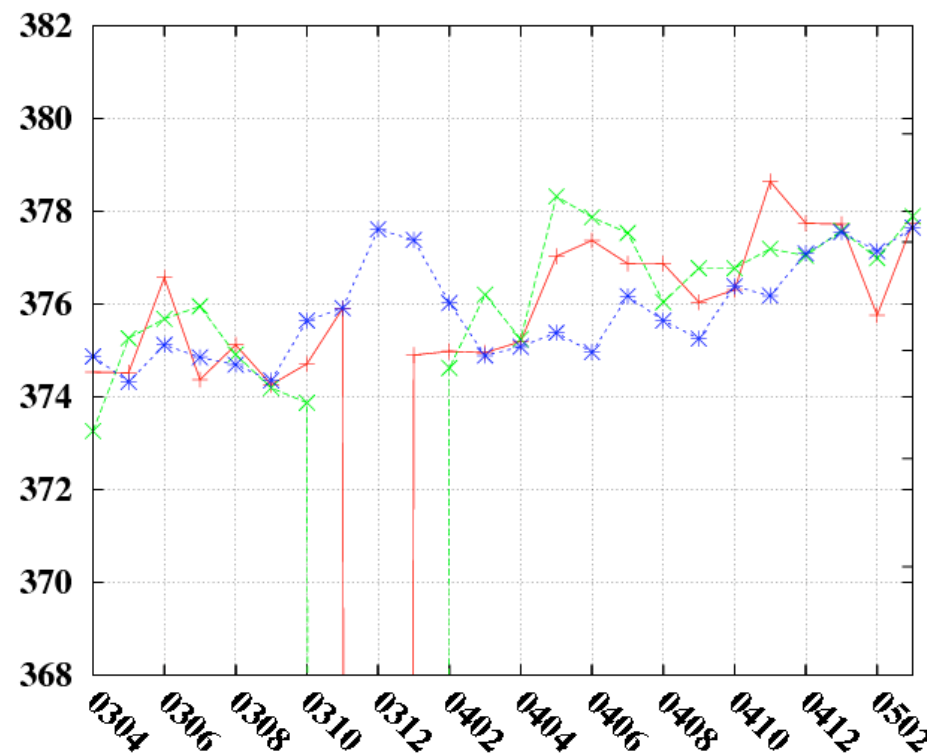
Comparison AIRS – Aircraft

- Aircraft 1st part of the month
- Aircraft 2nd part of the month
- AIRS

10S-15S



15S-20S



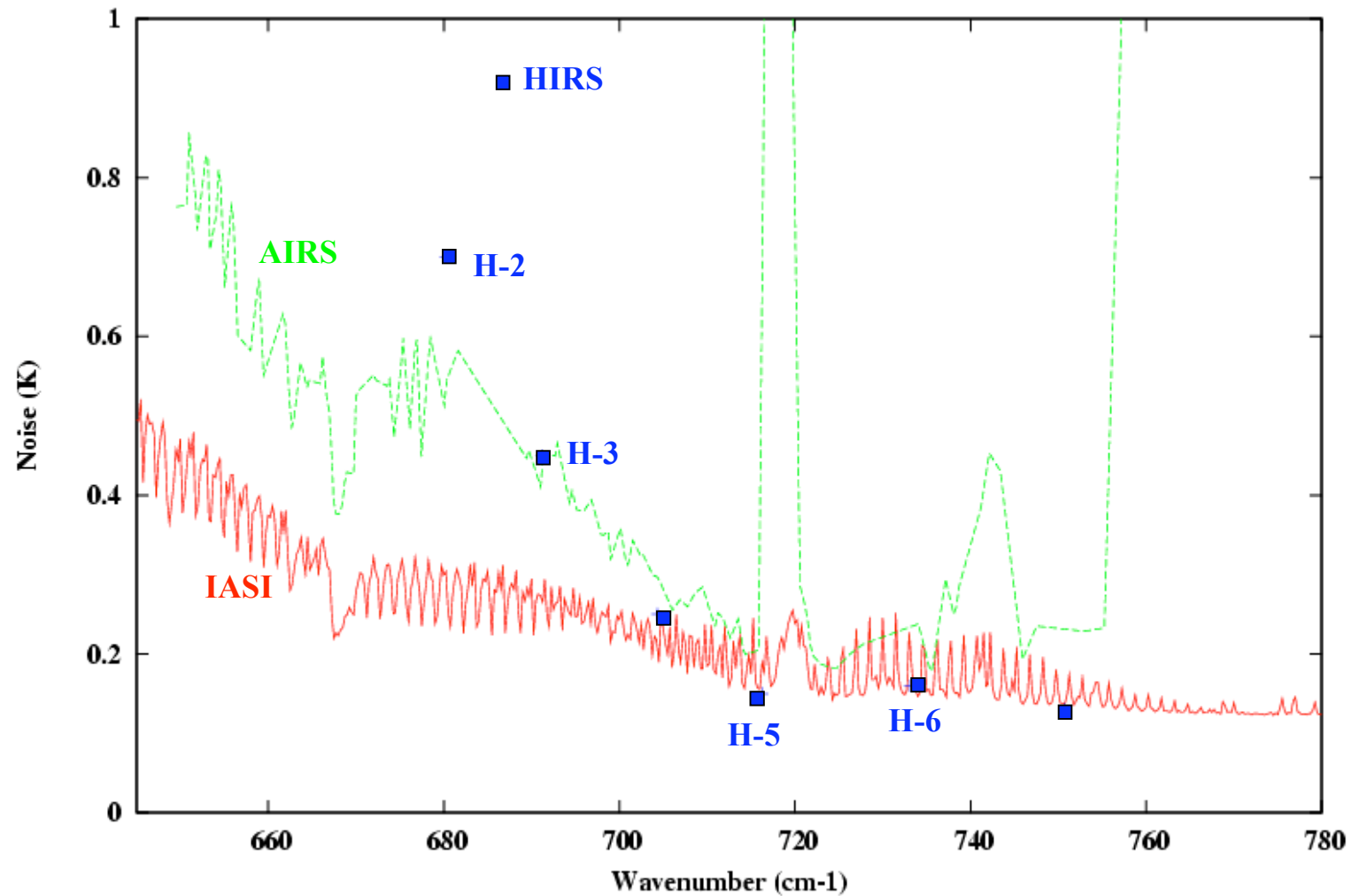
Comments on these preliminary results

1. Significant **dispersion** of the aircraft measurements within a month
2. Lack of in situ data from Nov. 2003 to Feb. 2004
3. Large variation of the **number of retrievals** available in the statistics :
a sufficient number is required to smooth out the noise
4. Poor agreement between in situ data and retrievals seen just after the pb.
encountered by AIRS : **October 2003 to January 2004 (included)**
5. **Relatively good agreement** seen before and after the above period with
some exceptions mostly due to too small a number of retrievals

Problems with AIRS

- **lack of AMSU-7** due to a very large noise: its weighting function almost exactly coincides with the CO_2 mean Jacobian. This very significantly degrades the quality of the decorrelation between CO_2 and temperature
- **icing problems** occurred in ~ November 2003. Seem to have lasted several months, at least at the “ CO_2 - accuracy” ! and, at least, looking at our present results.
However, not proven
- **discontinuous** 324 channel list: supplementary list under construction for CO_2 as well as for CH_4 (a few tens)
- **AIRS noises** slightly larger than for IASI in the LW

Noises at scene temperature* for HIRS, AIRS, and IASI



*Tropical atmosphere

Under development*

- 1. Refinement of the cloud and aerosol mask for AIRS (completed over sea at night) and for IASI (much attention paid to thin cirrus, aerosols, land emissivity)**
- 2. New learning data set (from F. Chevallier "SAF" data set) : partly done for AIRS, almost done for TOVS, to be done for IASI**
- 3. Reprocessing of AIRS observations (April 2003 - now ...). Study of the impact on carbon sources and sinks inversion (cooperation: LSCE/IPSL)**
- 4. Selection of IASI CO₂ - channels (first list, Jacobians, and sensitivities completed)**
- 5. Selection of IASI CH₄ channels (first list: at most 6-8 acceptable channels around 7.7 μm)**
- 6. IASI retrieval simulations and performance comparisons against both AIRS and TOVS**

*** In particular for the EU contract GEMS (PI-LMD: A. Chédin)**